Key

Chemistry: ***Chemical Word Equations***
Directions: *Write a balanced chemical equation for each of the word equations below.*

1. Aqueous sodium chloride reacts with aqueous lead (II) nitrate to yield a lead (II) chloride precipitate and aqueous sodium nitrate.

$2\,NaCl(aq) + Pb(NO_3)_2(aq) \rightarrow PbCl_2(s) + 2\,NaNO_3(aq)$

2. Aqueous barium nitrate reacts with sulfuric acid to yield a barium sulfate precipitate and nitric acid.

$Ba(NO_3)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2\,HNO_3(aq)$

3. Silver nitrate reacts in solution with potassium chromate to yield a silver chromate precipitate and soluble potassium nitrate.

$2\,Ag(NO_3)(aq) + K_2CrO_4(aq) \rightarrow Ag_2CrO_4(s) + 2\,KNO_3(aq)$

4. Solid calcium carbonate reacts with hydrochloric acid to yield aqueous calcium chloride, carbon dioxide gas, and liquid water.

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

5. Aqueous zinc chloride reacts with dihydrogen monosulfide gas to yield a zinc sulfide precipitate and hydrochloric acid

$ZnCl_2(aq) + H_2S(g) \rightarrow ZnS(s) + 2HCl(aq)$

6. Magnesium nitrate reacts in solution with potassium hydroxide to yield a magnesium hydroxide precipitate and soluble potassium nitrate.

$Mg(NO_3)_2(aq) + 2KOH(aq) \rightarrow Mg(OH)_2(s) + 2\,KNO_3(aq)$

7. Solid aluminum hydroxide reacts with nitric acid to yield soluble aluminum nitrate and liquid water.

$$Al(OH)_3(s) + 3HNO_3(aq) \rightarrow Al(NO_3)_3(aq) + 3H_2O(l)$$

8. Aqueous lead (IV) nitrate reacts with aqueous sodium sulfate to yield a lead (IV) sulfate precipitate and soluble sodium nitrate.

$$Pb(NO_3)_4(aq) + 2Na_2SO_4(aq) \rightarrow Pb(SO_4)_2(s) + 4NaNO_3(aq)$$

9. Aqueous sodium hydroxide reacts with carbon dioxide gas to yield soluble sodium carbonate and liquid water.

$$2NaOH(aq) + CO_2(g) \rightarrow Na_2CO_3(aq) + H_2O(l)$$

10. Solid magnesium oxide reacts with hydrochloric acid to yield a solution of magnesium chloride and liquid water.

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

11. Solid zinc metal reacts with sulfuric acid to yield aqueous zinc sulfate and hydrogen gas.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

12. Solid ferric oxide reacts with solid aluminum metal to yield solid aluminum oxide and solid iron metal.

$$Fe_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Fe(s)$$

Name: Key

Chemical Word Equations Review

1. Combustion in automobile engines takes place when fuel and oxygen are combined and ignited in the cylinders of the engine; however, the air that provides the oxygen for combustion also introduces nitrogen into the engine. The nitrogen reacts with oxygen at the high temperatures present in the engine, producing nitrogen oxide compounds, which are a major component of smog. In one of these reactions, nitrogen monoxide gas reacts with oxygen gas to form nitrogen dioxide gas. Write the balanced equation for this reaction.

$2\,NO_{(g)} + O_{2(g)} \rightarrow 2\,NO_{2(g)}$

2. During the centuries following the collapse of the western Roman Empire, marble (calcium carbonate) was taken from the monuments of Rome and heated to form quickline (calcium oxide), which was a solid used to make plaster. Carbon dioxide gas was also produced in this decomposition reaction.

$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

3. Aluminum sulfate and calcium hydroxide are used in water-purification process. They dissolve and react to produce two insoluble products, aluminum hydroxide and calcium sulfate. These products then settle out, taking suspended solid impurities with them. Write a balanced chemical equation for the reaction of aluminum sulfate and calcium hydroxide.

$Al_2(SO_4)_{3(aq)} + 3\,Ca(OH)_{2(aq)} \rightarrow 2\,Al(OH)_{3(s)} + 3\,CaSO_{4(s)}$

4. A useful single replacement reaction involves thermite, which is a mixture of solid aluminum and solid iron(III) oxide. When the thermite reaches a high temperature, the components react to produce molten iron and aluminum oxide solid, along with a great deal of energy.

$2\,Al_{(s)} + Fe_2O_{3(s)} \rightarrow 2\,Fe_{(l)} + Al_2O_{3(s)}$

5. Acid indigestion can occur when the stomach produces too much hydrochloric acid. An old and effective remedy for this involves drinking a solution of baking soda (sodium bicarbonate), which reacts with the hydrochloric acid to produce aqueous sodium chloride, water, and carbon dioxide gas.

$HCl_{(aq)} + NaHCO_{3(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

6. A problem with the remedy given in problem 5 for acid indigestion is that the carbon dioxide produced can cause discomfort. In many modern antacids, the active ingredient is solid magnesium hydroxide. When this compound reacts with the hydrochloric acid, a double-displacement reaction occurs that produces only water and aqueous magnesium chloride.

$Mg(OH)_{2(s)} + 2HCl_{(aq)} \rightarrow 2H_2O_{(l)} + MgCl_{2(aq)}$

7. Automobile airbags rely on the decomposition of the solid compound sodium azide (NaN_3) to produce the nitrogen gas needed to rapidly inflate the bag. Sodium metal is also produced in this decomposition reaction.

$2NaN_{3(s)} \rightarrow 3N_{2(g)} + 2Na_{(s)}$

8. Zinc metal reacts with water to produce aqueous zinc hydroxide and hydrogen gas.

$Zn_{(s)} + 2H_2O_{(l)} \rightarrow Zn(OH)_{2(aq)} + H_{2(g)}$

9. Carbon tetrachloride is used as an intermediate chemical in the manufacture of other chemicals. It is prepared in liquid form by reacting chlorine gas with methane gas (CH_4). Hydrochloric acid is also formed in this reaction.

$4Cl_{2(g)} + CH_{4(g)} \rightarrow CCl_{4(l)} + 4HCl_{(aq)}$

Chemical Equation Practice: The Haber Process

The Haber process, also called the Haber–Bosch process, is the nitrogen fixation reaction of nitrogen gas and hydrogen gas, over an enriched iron catalyst, to produce ammonia. The Haber process is important because ammonia is difficult to produce on an industrial scale, and the fertilizer generated from the ammonia is responsible for sustaining one-third of the Earth's population. By far the major source of the hydrogen required for the Haber-Bosch process is methane (carbon tetrahydride) from natural gas, obtained through a process called heterogeneous catalysis. Write the chemical reactions used in these processes below:

1) Methane gas is reacted with steam over a catalyst of nickel (II) oxide to form carbon monoxide gas and hydrogen gas. This is called steam reforming:

$CH_{4(g)} + H_2O_{(g)} \xrightarrow{NiO} CO_{(g)} + 3H_{2(g)}$

2) Secondary reforming then takes place using the oxygen gas in air to convert the methane that did not react during steam reforming. Two reactions take place: (a) one forming carbon monoxide and hydrogen gas, while (b) the other reaction forms carbon dioxide and water.

a. $2\,CH_{4(g)} + O_{2(g)} \rightarrow 2\,CO_{(g)} + 4H_{2(g)}$

b. $2\,CH_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(g)}$

3) Next, the water gas shift reaction yields more hydrogen gas from carbon monoxide gas and steam. to form hydrogen gas, with carbon dioxide gas as a by-product.

$H_2O_{(g)} + CO_{(g)} \rightarrow H_{2(g)} + CO_{2(g)}$

4) The gas mixtures that are products from Steps 1 and 2a are now passed into a methanator, which converts most of the remaining carbon monoxide into methane gas for recycling forming water in the process. This last step is necessary as carbon monoxide poisons the catalyst used in the Haber process.

$CO_{(g)} + 3H_{2(g)} \rightarrow CH_{4(g)} + H_2O_{(g)}$

5) The final stage, which is the actual Haber process, is the synthesis of ammonia using a form of magnetite, Fe_3O_4, as the catalyst. Atmospheric nitrogen gas is reacted with the hydrogen gas formed throughout Steps 1- 4 to make ammonia gas:

$N_{2(g)} + 3H_{2(g)} \xrightarrow{Fe_3O_4} 2\,NH_{3(g)}$

Chemical Equation Practice: Extraction of Iron from Iron Ore

Ninety percent of all mining of metallic ores (which look like rocks) is for the extraction of iron. Industrially, iron is produced starting from iron ores, principally hematite (Fe_2O_3) and magnetite (Fe_3O_4) by a carbothermic reaction (reduction with carbon) in a blast furnace at temperatures of about 2000 °C. In a blast furnace, iron ore, carbon in the form of coke (a solid), and a flux such as limestone (which is used to remove impurities in the ore which would otherwise clog the furnace with solid material) are fed into the top of the furnace, while a blast of heated air is forced into the furnace at the bottom.

1) In a blast furnace, coke is mixed with the oxygen in a blast of air to produce carbon monoxide gas:

$2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)}$

2) The carbon monoxide mixed with the iron ore hematite causes the formation of molten iron, and carbon dioxide gas is produced in the process:

$3CO_{(g)} + Fe_2O_{3(s)} \rightarrow 2Fe_{(l)} + 3CO_{2(g)}$

3) The flux is present to melt impurities in the ore, principally silicon dioxide sand and other silicates. Common fluxes include limestone (principally calcium carbonate) and dolomite (calcium-magnesium carbonate). Other fluxes may be used depending on the impurities that need to be removed from the ore. In the heat of the furnace the limestone flux decomposes to calcium oxide (quicklime) with carbon dioxide gas production in this process also:

$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

4) Then the calcium oxide combines with silicon dioxide solid (in the heat of the furnace) to form molten calcium silicate (the silicate ion is SiO_3^{-2}), which is called a *slag*:

$CaO_{(s)} + SiO_{2(s)} \rightarrow CaSiO_{3(l)}$

The slag melts in the heat of the furnace. In the bottom of the furnace, the molten slag floats on top of the denser molten iron, and apertures in the side of the furnace are opened to run off the iron and the slag separately. The iron once cooled, is called pig iron, while the slag can be used as a material in road construction or to improve mineral-poor soils for agriculture.